

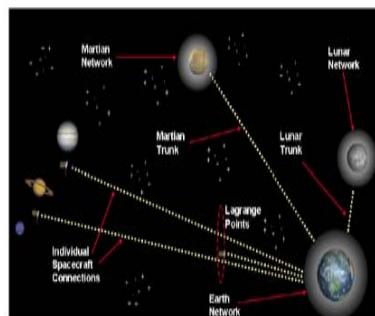


Homeland Security Collaboration Opportunities

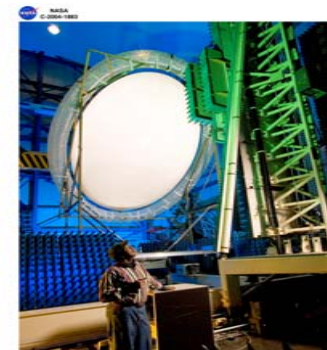
Robert J. Shaw
Chief, Business Development and
Partnership Office
NASA Glenn Research Center



High altitude observation
platform with photovoltaic arrays



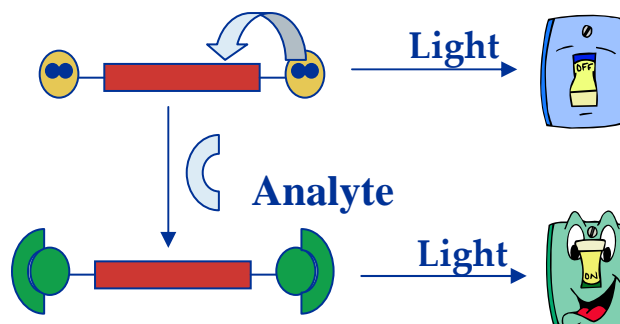
Communication architectures



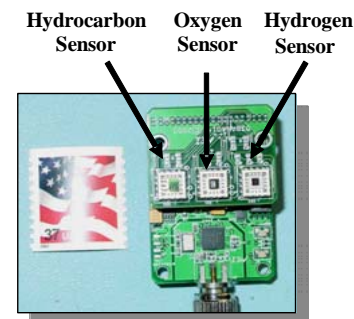
Inflatable antenna



Micro-computed tomography



“Sarin” florescent detector- on/off
electron transfer



“Lick and stick”
chemical sensors



Version and Audit Information

Version : GRCHomelandSecurityCompetencies (5-7-08)

Disclaimer:

These charts continue to be updated and redesigned. We recommend that you check with Lynn Boukalik, (216 433-9701) (lynn.h.boukalik@nasa.gov) to ensure that you have the latest version. We are also maintaining an audit list of where this file is distributed, please tell us if you have distributed the file to others.



Ground breaking for the NACA Aircraft Engine Research Laboratory January 23, 1941



Glenn Research Center's Two Campuses



Cleveland (Brook Park and Fairview Park)

- 350 acres
- ~1600 civil servants and 1200 contractors

Plum Brook (Sandusky)

- 6400 acres
- ~10 civil servants and 80 contractors





Civil Service Workforce

- 75% of workforce charges their time directly to the technical mission
- 67% of scientists and engineers have advanced degrees, 25% with earned Ph.D's



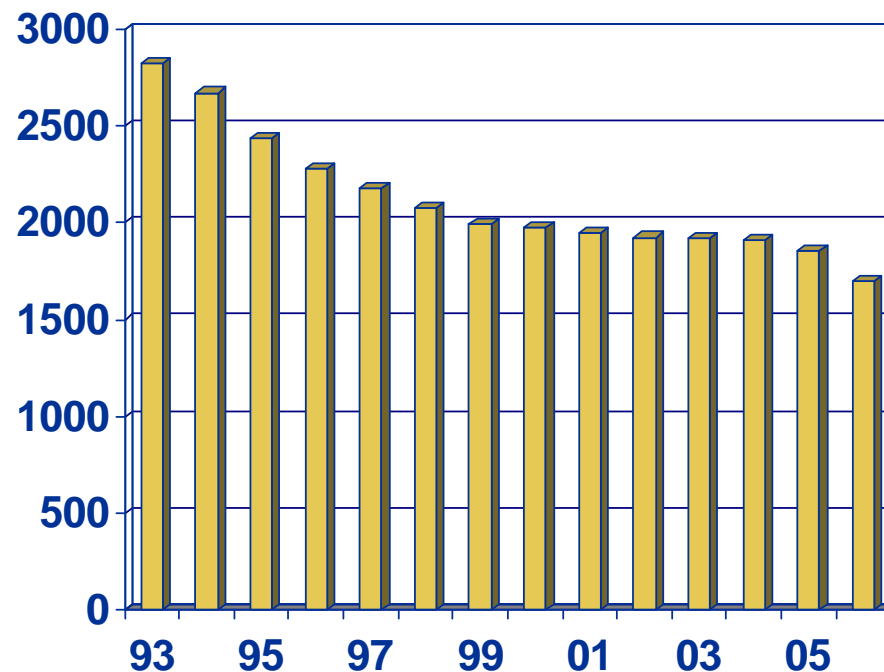
**Administrative
and Clerical**



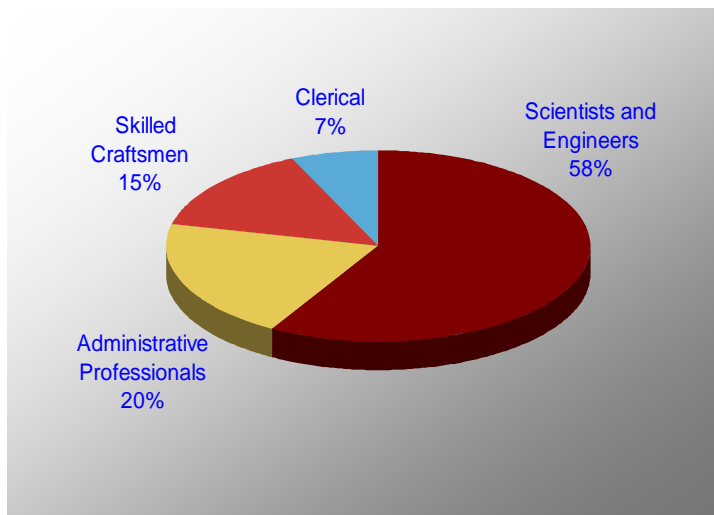
**Scientists and
Engineers**



**Skilled
Craftsman**



■ FTE





Mission and Product Lines

- Glenn Research Center is a NASA Field Center with the top priority to support the Agency's four **missions**:
 - Space Exploration
 - Space Operations
 - Earth and Space Science
 - Aeronautics
- GRC's major **product lines** of power, propulsion, and communications are critical to achieving the Agency's future objectives.



Competencies and Partnerships

- The **competencies** required to produce technologies for these major product lines are well aligned with priority national objectives.
- GRC will aggressively look to form **partnerships and seek new business opportunities** that fit the following criteria:
 - GRC competencies are required and the proposed effort will either maintain or strengthen those competencies.
 - The business case is positive for both our partner and GRC.



GRC Competencies

Competencies	Glenn Research Center Facilities at Lewis Field or Plumbrook Station	Notes
Acoustics	Acoustic Dome (p 3**)	
Bio-Engineering	Several R&D labs	Recently established thrust
Combustion	Space Combustion Facilities, Combustion R&D Labs (p 24**)	2 detailed charts in Appendix
Communications	Antenna Test Facility, Communications Testbed, 35 R&D labs	5 detailed charts in Appendix
Electric (Ion) Propulsion	Space Simulation Vacuum Chambers (p 27**)	Battery powered ground vehicle – 70's-90's. Includes power
Electrical Systems	Spacecraft Electrical Systems Test Bed (p 30**)	Power – generation, management, distribution
Electrochemistry-Physics	Fuel Cell Test Facilities (p 31**)	Includes power, fuel cells and batteries. Some staff embedded in related competencies
Fluids, CFD, TurboMachinery	Engine Research Facilities, Icing Wind Tunnel (p 13**)	This competency supported Wind Turbine development in the 1970's and 1980's. Wind turbines could also include Structures, Materials, Mechanical Components, Acoustics and Icing. 6 detailed charts in Appendix
Instrumentation, Controls, Electronics	31 R&D Labs, Clean Rooms (p 33**)	3 detailed charts in Appendix
Materials	142 R&D Labs, Large Multi-Axial Fatigue Facility (p 32**)	5 detailed charts in Appendix

** Facilities Brochure

<http://www.nasa.gov/centers/glenn/testfacilities/>



GRC Competencies

Competencies	Glenn Research Center Facilities at Lewis Field or Plumbrook Station	Notes
Mechanical Components and Lubrication	Space Mechanisms Labs, Tribology R&D lab	
Modeling, Simulation & Visualization	Graphics and Visualization Laboratory, Cluster Computing (p 35**)	See Fluids, Combustion, Structures, Acoustics, BioTech and Communications
Nanotechnology	Several Labs Included In Other Competencies	See Electrochemistry-Physics, Photovoltaics, Instrumentation, and Materials
Photovoltaics	Photovoltaic R&D Laboratories	Includes power
Program/Project Management	See Others	
Propellant Systems	Space Cryogenic Testing Facilities (p 25**)	Liquid Hydrogen systems/storage; Boron Nitride nanotubes being evaluated for gaseous hydrogen storage
Structures	62 R&D Labs (p 33**)	3 detailed charts in Appendix
Systems Analysis	World-Class Aerospace Analysis Tools	
Systems Engineering	Development and Verification Labs	
Thermal Energy Conversion	Power Systems Facility	Includes power

** Facilities Brochure

<http://www.nasa.gov/centers/glenn/testfacilities/>



Homeland Security Research and Development

Competencies

Prevention

(shipping from overseas ports)

Detection

(explosives, radiation, biological)

Follow-up

(clean-up processes)

Bio-Engineering
Communications
Fluids, CFD,
Turbomachinery

Modeling, Simulation
& Visualization

Systems Analysis

Systems Engineering

Inspection at foreign ports

Sealed-tamperproof
containers

High damage-tolerant
containers

Re-inspection USA ports

Safe unpacking and distribution

Electronic tracking and
communications

Border observation and tools

Sensors

- Accurate
- Liquids gases and solids
- Laser technology

analysis

- Robotics

Communication

- Airships
- High-speed integrated network
- Video recognition and analysis

Communications
with stakeholders

Cross Cutting Competencies

Instrumentation, Controls, Electronics

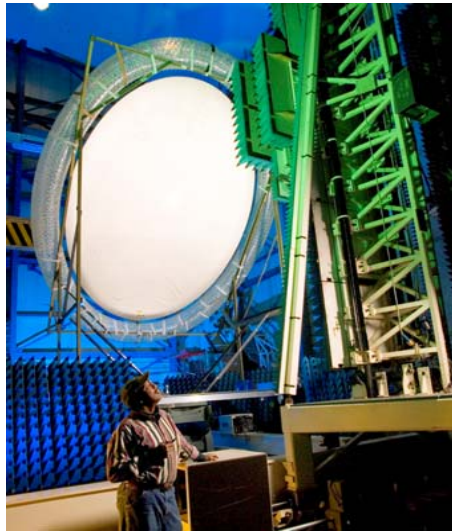
Materials

Nanotechnology

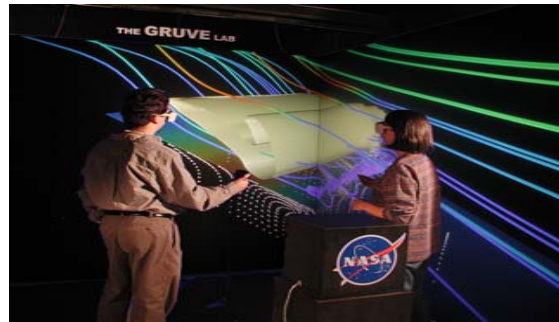
Program/Project Management

Structures

Selected Homeland Security Labs and Facilities



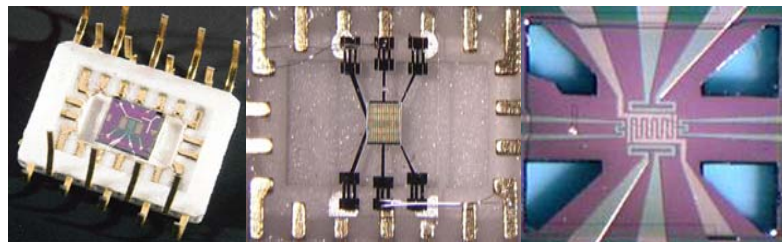
Near field antenna facility



Glenn Reconfigurable User-interface
and Virtual Reality Exploration Lab



Software reconfigurable signal
processing platform



Sensors lab - (Hydrogen, Oxygen and Carbon Dioxide)



Instrumentation and controls lab



Portable unit for metabolic analysis



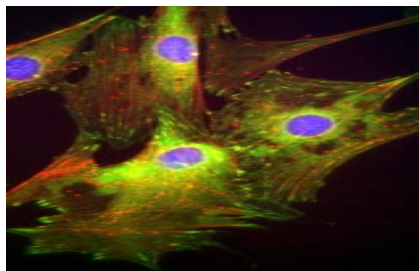
Network emulator lab

Bio-Engineering



Description

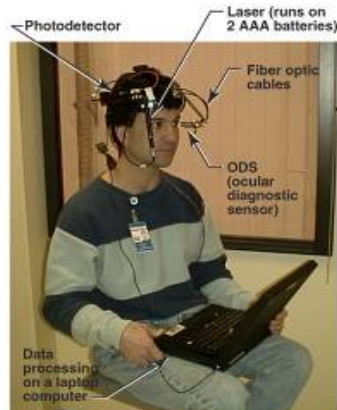
- Research and technology development to support human exploration of space
- Interdisciplinary research to develop revolutionary technologies needed for aeronautics missions



**Two-photon microscopy
images of cells**

Focus Areas

- Advanced biomedical diagnostics and instrumentation
- Modeling the effects of the space exploration environment on physiological components and systems.
- Biomedical sensors for space application
- Countermeasure systems to preserve human health during space exploration
- Advanced Fluid Systems for crew health care
- Computational simulations quantifying risk to crew health and mission



**Prototype of head
mounted eye disease
monitoring systems**



**Exercise
countermeasures**

Facilities/Labs

- Bio-photonics lab
- Vision lab
- Cell culture lab
- Zero-Gravity Analog Exercise Countermeasures Lab
- Physiological Systems Computational Cluster
- Ultrasound and Advanced Diagnostics Lab
- Drop towers, sounding rockets, KC-135 and space station

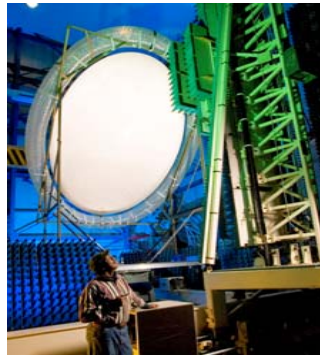
Accomplishments

- Development of eye disease monitoring system (2005)
- Improved understanding of bone loss and cardiac response in weightless environment (2006)
- Development of advanced fluorescence microscopy techniques to study cell physiology (2005/6)
- Virtual reality treadmill developed with Cleveland Clinic to maintain neurovestibular equilibrium in astronauts(2004)
- Portable Unit for Metabolic Analysis (PUMA) demonstration during NASA's undersea mission (2007)
- Constructed aero-gravity analog treadmill with vibration isolation and stabilization as a platform to quantify reduced gravity exercise and task efficacy (2006–present)
- 1st quantitative probabilistic risk assessment of bone fracture risk during exploration missions (2007)

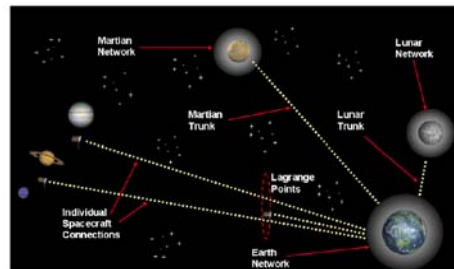
Communications

Description

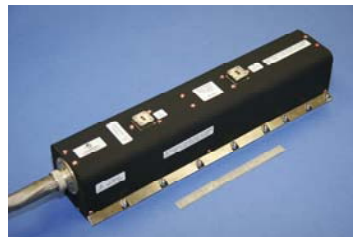
- Increased capacity communication systems maximizing information throughput, performance and portability for space, surface, mobile and aeronautical applications
- Development of communications systems and networks based on technologies that include radio frequency components and devices, digital and wireless communications systems, ground systems and communications networking techniques.



Near field antenna facility



Architecture



High efficiency 200 watt traveling wave tube

Facilities/Labs

- Antenna ranges including near- and far-field antenna ranges, compact range, cylindrical near field range
- Radio frequency propagation laboratories
- Electronic component fabrication and characterization laboratories
- Network emulation laboratory
- Digital systems laboratory
- Space telecommunications radio system lab

Accomplishments

- Demonstrated large (4m x 6m) class aperture deployable antennas (2005)
- Antenna element trade-off for Tracking and Data Relay Satellite System multiple access antenna (2006)
- Software defined radio architecture framework for space-based radios (2006),
- Space network router (2005)
- High Efficiency 200 W Traveling Wave Tube Amplifier
- High speed, Spacewire® networking interface controller (2006)
- Inter-spacecraft communications and ranging system (2005)
- Demonstrated the effective use of Ka Band for Space Communications (1995)

Focus Areas

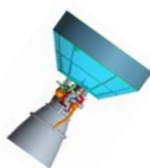
- Large-aperture and miniaturized antennas.
- Ka-band atmospheric calibration studies
- Software defined radios
- Low power, reconfigurable transceivers
- Signal processing and networking devices
- Radio frequency amplifiers and devices
- Communications networks based on Internet Protocols
- Providing the highest integrity, end-to-end system solutions.

Fluids, CFD and Turbomachinery

Description

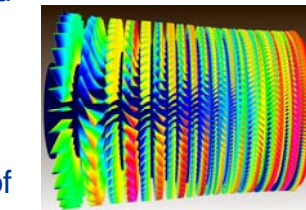
- Perform experimental and computational fluid dynamic (CFD) research for design and development of inlet and exhaust systems
- Research data from test facilities and computational codes for design tools and methodologies to advance the understanding of inlet and nozzle related flow physics, operability efficiency and turbine cooling capabilities
- Explore the fundamental principles of physics and chemistry through fluids research in the unique natural laboratory of space

Thrust vector control

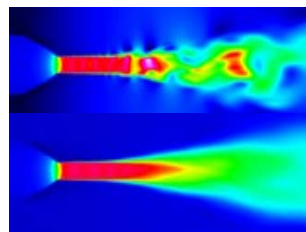


Instantaneous

Time-Averaged



RANS and LES simulation of compressors



Large eddy simulation of mach 1.4

Facilities/Labs/Tools

- Supersonic wind tunnels (10'x10', 8'x6', 1'x1')
- Low speed wind tunnel (9'x15')
- Static nozzle test facility
- 15cm x 15cm SWT- fundamental flow physics
- Diffuser test rig- evaluation of subsonic diffusers
- Low speed compressor test facility
- Single spool turbine test facility
- Multistage and single stage test facilities
- Turbine film cooled vane facility
- Transonic turbine blade cascade
- Vibration and Statics Load Lab
- Mechanical design using Pro/Engineer
- Mechanical analysis (NASTRAN, ANSYS, ADAMS)
- Drop towers, sounding rockets and space station

Accomplishments

- Mach 2.4 external compression inlet concept developed (2005)
- Conducted first microgravity tests of water reclamation system for spacecraft (2006)
- Aerodynamic testing of a highly loaded multi-stage axial compressor with 4.5 pressure ratio (2006)
- Developed Large Eddy Simulation technique for turbomachinery flow analysis. (2005)
- Tip gap aerodynamic and heat transfer measurements in transonic turbine cascade (2004)
- Completed performance tests of wave rotor (2006)
- Developed lunar rover test bed (2006)



Focus Areas

- Multiphase flows and phase changes
- Model development (vortex generators, bleed, turbulence, inlet/fan integration)
- Code development (Wind, APNASA, GLENN-HT)
- Multistage compressor and turbine CFD code development
- Conjugate heat transfer turbine CFD code development
- Large Eddy Simulation method development for fan, compressor and pump analysis
- Development of Reynolds Averaged Navier-Stokes code (RANS)

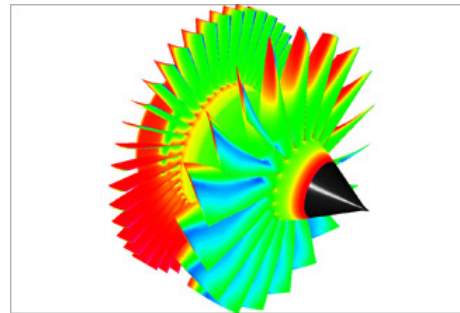
Modeling, Simulation, and Visualization

Description

- Design and analysis of component and system operations
- Support design of new technologies
- Provide detailed understanding of experimental data



3D iced inlet simulation



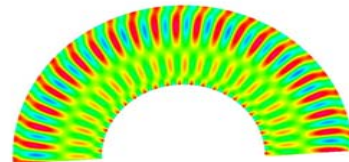
3D engine simulation

Facilities/Labs/Tools

- NASA Ames Columbia supercomputer
- Advanced computational concepts laboratory
- Glenn Reconfigurable User-interface and Virtual Reality Exploration Lab
- Large scale Linux clusters (~6)

Focus Areas

- Aircraft and rocket propulsion
- Ice accretion
- Noise prediction
- Virtual reality techniques
- Microgravity environments
- Cryogenic fluid management
- Fire safety in space habitats
- Spacecraft power systems
- Materials modeling/analysis
- Astronaut health/biotechnology
- Spacecraft mission analysis/design



Noise analysis

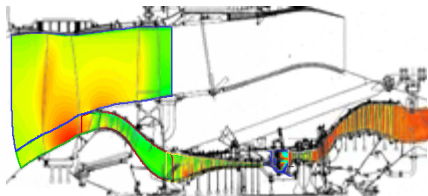
Accomplishments

- Numerical Propulsion System Simulator reduces analysis time by 55% (2001)
- TURBO-AE used by Air Force and 20 companies (1995 to present)
- Significant engine noise reduction achieved utilizing GRC codes (15 unique codes)
- System power analysis trade capability for the International Space Station (2003)
- Commercialized micromechanics analysis code with Generalized Method of Cells, Ceramics Analysis and Reliability of Structures and GENOA-Progressive Failure Analysis (1999)
- LEWICE 2D/3D (LEWIS ICE accretion program) utilized by industry to design more efficient aircraft deicing systems for safe operations (2006)
- Virtual treadmill collaborations with Cleveland Clinic for astronaut health monitoring (2004)
- SIZER enables preliminary vehicle synthesis, sizing and scaling functionality for mission planners and requirements analysis

Systems Analysis

Description

- Unique analysis abilities and tools
- Analysis of vehicle synthesis
- Mission analysis/design
- Propulsion and power analysis
- Concept development
- Aero safety analysis



Aeropropulsion



Lunar Lander

Facilities/Labs/Tools

- Numerical Propulsion System Simulator (NPSS)
- Structural Airfoil Blade Engineering Routine (SABER)
- Flight Optimization System (FLOPS)
- Orbital Trajectory by Implicit Simulation (OTIS)
- Space Power Analysis for Capacity Evaluation (SPACE)
- Process Based Economics Analysis Tool (PBEAT)
- Logic Evolved Decision (LED)

Focus Areas

- Architecture studies
- Space mission operations
- System trade studies
- Program support
 - Requirement definitions
 - Analytical analysis
 - Independent verification and validation
 - Metrics, earned valued
- Independent reviews
- Assess technologies
 - Gaps, benefits
- Methods development



Rocket propulsion

Accomplishments

- Green propellant thermal cycle evaluation (2006)
- International Space Station vacuum power design (2006)
- Flight Performance Systems Integration Group (2006)
- Analysis of Crew Exploration Vehicle/Crew Launch (2006)
- Vehicle power and trajectory (2006)
- Lunar Surface Access Module designs (2006)
- Lunar surface power architecture (2006)
- Cargo launch vehicle design (2006)
- Engineering based cost analysis (2006)
- Proposal development and evaluation (2006)
- Delta 3 oxygen/hydrogen upper stage historical repository of data (2006)

Systems Engineering

Description

- Development and maintenance of systems engineering processes
- Application of systems engineering processes at a system level
- Technical management of systems

Facilities/Labs/Tools

- Commercial software codes:
 - DOORS®
 - Cradle®

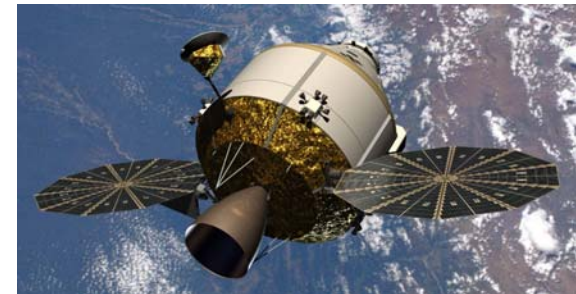
Crew Exploration Vehicle



Crew Launch Vehicle



Space Station Fluids and Combustion Facility



Crew Exploration Vehicle



**Delta-III Vehicle
in B-2 facility**

Focus Areas

- System development
- Requirements development and management
- Verification and validation planning
- System integration
- Technical decision analysis
- Technical reviews

Accomplishments

- Successful development, integration and operations of microgravity experiments on shuttle and station (1992-present)
- Leading the development of requirements for the Crew Exploration Vehicle (2005-present)
- Leading the systems engineering on various portions of the Crew Exploration Vehicle and Crew Launch Vehicle (2005-present)
- Accelerated training program for new systems engineers (2006)



Homeland Security Research and Development

Competencies

Bio-Engineering
Communications

Fluids, CFD,
Turbomachinery

Modeling, Simulation
& Visualization

Systems Analysis

Systems Engineering

Prevention

(shipping from overseas ports)

Inspection at foreign ports

Sealed-tamperproof
containers

High damage-tolerant
containers

Re-inspection USA ports

Safe unpacking and distribution

Electronic tracking and
communications

Border observation and tools

Detection

(explosives, radiation,
biological)

Sensors

- Accurate
- Liquids gases and solids
- Laser technology analysis

Communication

- Airships
- High-speed integrated network
- Video recognition and analysis

Follow-up

(clean-up
processes)

Communications
with stakeholders

Cross Cutting Competencies

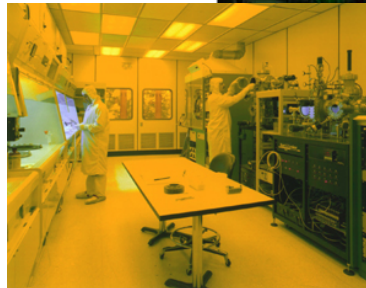
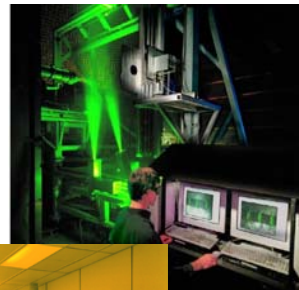
Instrumentation, Controls, Electronics
Materials
Nanotechnology
Program/Project Management
Structures

Instrumentation, Controls and Electronics



Dynamic modeling

Particle imaging velocimetry for jet noise characterization



Microsystems facilities



Portable unit for metabolic analysis

Facilities/Labs

- Dynamic modeling
- Propulsion health monitoring
- Particle imaging velocimetry
- Flight electronics lab
- Micro computed tomography
- Microsystems fabrication clean rooms
- Silicon Carbide chemical vapor deposition
- Harsh environment micro/nano-device laboratories
- Cryogenic testing chambers (5) to near absolute zero
- Environmental testing facilities (vacuum, temperature, humidity control)

Description

- Sensor development for harsh environments
- Optical instrumentation and NDE
- Controls and dynamics
- Design, development and testing for space flight instrumentation
- Digital circuit board design and analysis for aerospace
- Electronics for cryogenic environment
- Intercalated graphite conductors and radiation shielding

Focus Areas

- Intelligent control and propulsion health monitoring and physics-based modeling
- Optical flow path measurements
- NDE methods development
- Silicon Carbide based electronic devices and MicroElectroMechanical Systems (MEMS)
- Robotics technology development
- Crew Exploration Vehicle avionics
- Crew Launch Vehicle data flight instrumentation and control system development/analysis
- Biomedical sensors for space applications

Accomplishments

- 1400 °C temperature sensitive paint sensor
- Zero false alarm fire detection system demonstrated (R&D 100 Award) (2005)
- High temperature (600°C) Silicon Carbide pressure transducer demonstrated (2006)
- Portable unit for metabolic analysis demonstration (2006)

Materials

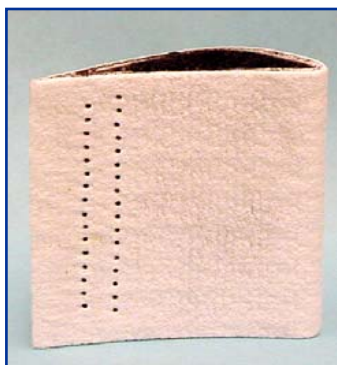
Description

- Advanced lightweight structural concepts and designs for aerospace applications
- Micromechanics and life prediction of aerospace components



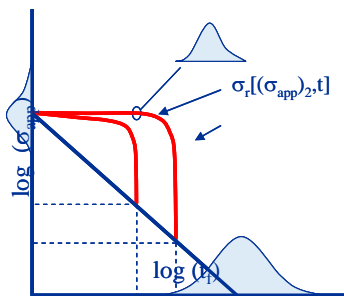
High temperature shape memory alloy (0.06 inch diameter wire)

Ceramic matrix composite vane with environmental barrier coating



Focus Areas

- Aerospace propulsion materials (metals, polymers, ceramics, coatings, composites) offering higher temperature capability and reduced weight
- Failure mode determination, damage mechanics, and life prediction methodology
- Multifunctional materials and structures
- Adaptive materials and structures
- Computational materials
- Nanotechnology materials



Probabilistic life prediction model

Facilities/Labs

- Facilities for processing, joining, and characterizing advanced polymeric, metallic, ceramic, composite materials and coatings
- Full range materials analytical facilities, including optical, electron, and atomic force microscopy, x-ray diffraction, spectroscopy and chemical analysis
- Over 100 world-class thermomechanical and subcomponent test facilities encompassing a wide range of temperature, environmental, and load regimes
- Atmospheric and high pressure burner rigs

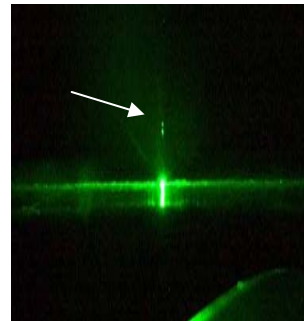
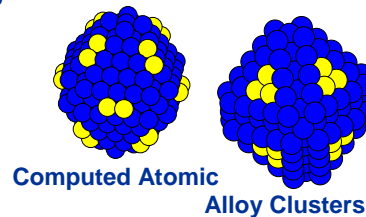
Accomplishments

- Shape memory alloy with 300 °C temperature capability (2006)
- Coated ceramic composite system for turbine vane (2005)
- Low density single crystal nickel-base superalloy (2006)
- Polymer cross linked aerogel (2006)
- Polymer nanocomposite (2006)
- Repair of reinforced carbon/carbon composite Space Shuttle tiles (2005)
- Integrated multiscale Micromechanics Analysis Code (2005)
- Advanced probabilistic structural analysis tool (2005)

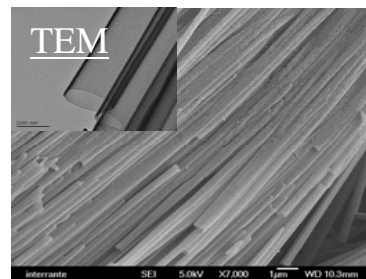
Nanotechnology

Description

- Modeling - atomistic computational alloy design
- Nanomaterials - synthesis of Boron Nitride, Metal Oxide, Carbon-nanotubes and smart polymeric materials for high temperature and harsh environment use
- Nanophotonics - optical trapping for device manipulation and fabrication
 - quantum dots/optical sources for low power quantum communication and sensing in extreme environments
- Nanoelectronics - harsh environment sensors and electronics for nano-electro-mechanical systems (NEMS) devices dynamic energy systems



Optical levitation of microscale particles



Silicon Carbide nanotubes

Facilities/Labs

- Desktop atomistic alloy nanoparticle modeling
- High temperature synthesis/processing facilities
- Inert atmosphere gloveboxes, clean rooms
- Thin film deposition chambers
- Laser tweezers
- Quantum entanglement optics lab and world class quantum optics systems
- Harsh environment NEMS research facility for prototype design, fabrication and characterization

Accomplishments

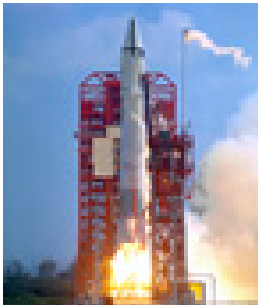
- Calculation of free surface energetics of nanoparticles (2004)
- Demonstrated Boron Nitride nanotube composite with superior hydrogen storage (2006)
- Detected Hydrogen with Tin Oxide electrospun nanofibers (2006)
- Experimentally verified a light propagation model for predicting light scattering from an optically trapped particle (2006)
- Quantum communication demonstrated over 75 meters at 10^{-18} Watt (2006)
- First demonstration of silicon Carbide nanotubes with controlled wall thicknesses (2004)

Focus Areas

- Free surface alloy energetics for designing novel alloys for solid-state hydrogen storage and low cost fuel cell catalysts
- Multifunctional high temperature materials for propulsion, sensors and communications
- Micro/nano device fabrication techniques for harsh environment and environmental hazard sensing and secure, ultra low power, high efficiency data transmission
- Design and fabrication of harsh environment NEMS materials and devices

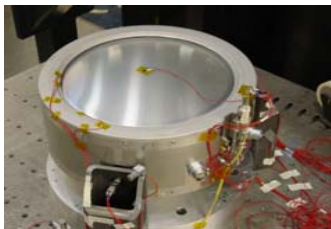


Program/Project Management



Centaur Launch Vehicles

- Managed 119 launches (1963-1997)
- Over 91% launch success rate



Electric Propulsion

- Invented first Hall and ion thrusters; designed, built and delivered Deep Space I Ion Engine



Space Station Freedom

- Designed the largest power system ever deployed in space



Aeropropulsion

- Managed Energy Efficient Engine Program, demonstrated 15% reduction in fuel consumption, enabling development of GE 90 turbine engine



Microgravity

- Over 90% success rate in developing/managing 130 microgravity experiments on Spacelab, Spacehab, Mir and International Space Station



Communications

- Developed first ever Ka band communications satellite
- Over 150 organizations in 31 states
- Conducted over 100 experiments

NASA Program/Project Management Training Levels

- 57 Level I Entry Level Project Managers
- 23 Level II Journey Project Managers
- 18 Level III Advanced Project Managers
- 6 Level IV Program Managers

Structures

Description

- Fluid-structure interaction
- Impact mechanics and energy absorbing structures
- Predicting and verifying structural dynamics responses, loads, vibration, acoustic, and shock environments for flight structures
- Structural and mechanical design from concept through fabrication and integration of aerospace flight structure
- Stress / deflection, modal, and buckling analysis
- Pressure vessel design and analysis

Focus Areas

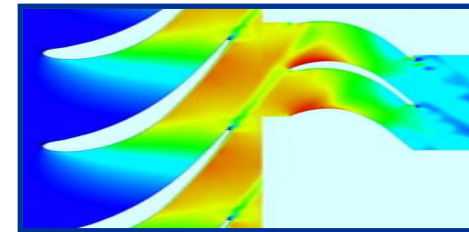
- Structural dynamics analysis of CEV/CLV components
- Ballistic impact testing and analysis of orbiter windows, leading edge, thermal protection system, and external tank materials
- High fidelity aeroelastic computational tools
- Space and launch environments
- Finite element modeling techniques



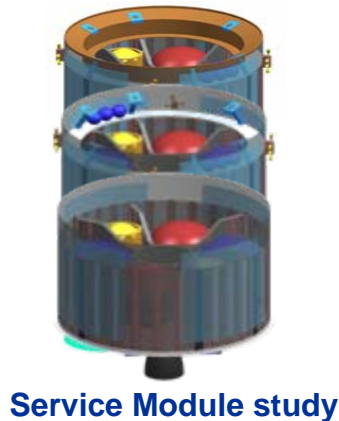
Ballistic impact lab

Facilities/Labs

- Aeroelastic and structural testing in supersonic and low-speed wind tunnels
- Ballistic impact test facility
- Structural statics and dynamics labs
- Acoustic testing lab



Fluid-structure interaction modeling



Service Module study

Accomplishments

- 3-D Navier-Stokes TURBO aeroelastic code developed and validated (2005)
- Ballistic impact tests and analysis to support the shuttle to the return to operational status (2005-06)
- Crew Exploration Vehicle spacecraft adapter lead role and Service Module structural design key role (2004 - present)
- Crew Launch Vehicle ARES I-1 upper stage segment structural loads and dynamics lead role (2004 - present)
- Concept studies for CEV Service Module have had direct impacts on Lockheed Martin's configuration (2006)



Partnership Contact

- Many of our current competencies (people, facilities) are aligned with current national needs regarding Homeland Security.
- We desire to partner, where appropriate, with organizations with organizations involved in Homeland Security.
- To continue our partnership exploration, please contact:
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- Glenn Research Center Websites
 - **Business Development and Partnership Office**
 - <http://newbusiness.grc.nasa.gov>
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 - <http://www.nasa.gov/centers/glenn/testfacilities/>
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 - <http://www.nasa.gov/centers/glenn/about/index.html>